FINAL

FLOOD DAMAGE REDUCTION ALTERNATIVES REPORT

ADDRESSING DOWNTOWN RENO BRIDGES

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Sacramento District

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PURPOSE

This report presents alternatives for reducing damages caused by flooding of the Truckee River in downtown Reno, Nevada. The information is intended to assist government officials and members of the public in determining the best options for reducing flood damages in the downtown Reno area. In turn this will support further progress in planning a regional flood management project which benefits Reno, Sparks, and Washoe County.

This is a special report intended to support plan formulation, particularly addressing options for flood damage reduction that take into account bridges constructed prior to 1940 in downtown Reno. This report is provided for information only and is not intended to fulfill the requirements of the National Environmental Policy Act or any other laws.

BACKGROUND

PAST FLOOD EVENTS

The geographic focus of this report is the downtown Reno reach of the Truckee River. The reach extends from Booth Street to Wells Avenue.

Reno has experienced high flows and flooding near or within town limits about a dozen times since 1907. Significant floods resulting from combined rainfall/snowmelt events occurred on the Truckee River in 1907, 1928, 1937, 1950, 1955, 1963, 1964, 1986, and 1997. Structures within the first several blocks adjacent to the river have at times become inundated by up to 6 feet of water. The 1997 event was the most devastating. Over 7,000 acres were flooded in the area, and damages totaled between $500 and $600 million. More than 800 people lost their jobs, and 15,000 additional jobs

were affected. Table 1 shows the peak discharge of the Truckee River, in cubic feet per second (cfs), during the six most recent flood events. In comparison to these flows, a discharge of 20,700 cfs is currently being used to evaluate the hydraulic effects of various flood protection alternatives for downtown Reno. This is the flow which is estimated to have a 1 in 100 chance (1 percent) of being exceeded in any given year ("100-year" design event).

Table 1

Summary of Most Recent Floods

Date of Flood	Peak Discharge (cfs)
November 1950	19,900
December 1955	20,800
February 1963	18,400
December 1964	11,300
February 1986	14,400
January 1997	23,000

FLOOD PROJECT AND COMMUNITY COALITION

To protect the Reno-Sparks Metropolitan area from flooding, in 1964 the U.S. Congress authorized and directed the U.S. Army Corps of Engineers (Corps) to conduct an investigation of water resource problems in the Truckee Meadows.

In 1985, the Corps completed feasibility studies, and in 1988 Congress authorized construction of a flood control project. In 1991, the Corps reevaluated project benefits and costs. It was determined that the project, as then formulated, was no longer economically feasible in part due to changes in the manner in which land costs were evaluated. Consequently, further work on the project was suspended. Then in 1996, due to the continued flood threat and interest by the local sponsors, the Corps commissioned a

reconnaissance study. The 1997 flood occurred during the study, necessitating a revision of the hydrologic record. The reconnaissance study's reassessment of the flood risk and its estimate of the benefits and costs led to the conclusion that a flood project once again appeared to be economically viable. Subsequently, efforts were reinvigorated to formulate a flood damage reduction and ecosystem reduction project that would be supported by the sponsors, and to evaluate its environmental effects.

In order to ensure that the reformulated project would reflect community concerns, a coalition of stakeholders was created in April 2000 by Reno, Sparks, and Washoe County, with encouragement from the Corps. The Truckee River Flood Management Community Coalition consists of representatives from over 50 organizations (local, state, and national) and numerous interested individuals. The Coalition provides a forum whereby project sponsors and members of the public can have their voices heard throughout the planning process. The goal of the Coalition is to develop a multi-objective flood management proposal that provides flood protection, is financially feasible, is acceptable to the community, improves the health of the Truckee River system, and offers recreation and river parkway benefits for the people who live there.

DOWNTOWN BRIDGES CONSTRUCTED PRIOR TO 1940

Three bridges in downtown Reno area, Virginia, Sierra, and Lake Street Bridges, are more than 60 years old and do not allow a flow of 20,700 cfs to pass underneath. Each bridge is of interest to the local historic preservation community. The Virginia Street Bridge is listed on the National Register of Historic Places. In 2002, Sierra and Lake Street Bridges, as well as other structures within the downtown reach of the project area, will be assessed for their eligibility for the National Register by the Sacramento District of the Corps as part of the planning of the regional project.

Sierra Street Bridge

The Sierra Street Bridge was designed by the Nevada Department of Highways and was built in 1937. According to the Nevada Department of Transportation (NDOT), the bridge is already eligible for rehabilitation and will soon be eligible for replacement under the Federal Highway Bridge Replacement and Rehabilitation Program (HBRRP) due to its deteriorated condition. NDOT's current view is that Sierra Street Bridge is not eligible for the National Register. The Corps is in the process of conducting its own evaluation of the bridge's eligibility for the National Register and will consult with the Nevada State Historic Preservation Office (SHPO) on the results of that evaluation.

Virginia Street Bridge

Construction of the Virginia Street Bridge began in July 1905. The bridge was opened to traffic 4 months later. Designed by John B. Leonard of San Francisco, the Virginia Street Bridge is the oldest bridge in Nevada. It is the fifth bridge located where Virginia Street crosses the Truckee River. The bridge was listed on the National Register in 1980. NDOT estimates that approximately 90 percent of the bridge's useful life has expired. Prolonged use, past flood events, and weathering have taken their toll on the bridge. Based upon NDOT's procedure for assessing structural condition and associated eligibility for funding under the HBRRP, the bridge has long been eligible for either rehabilitation or replacement.

In 1996, a Memorandum of Agreement (MOA) was signed by the Federal Highway Administration (FHWA), the SHPO, and the Federal Advisory Council on Historic Preservation for the reconstruction of the Center Street Bridge and the rehabilitation of the Virginia Street Bridge. The agreement stated the FHWA would ensure that the Virginia Street Bridge would be rehabilitated in a manner that preserves its historical and architectural value. The City of Reno and the NDOT concurred with the MOA's contents and also signed the agreement.

Lake Street Bridge

The Lake Street Bridge was designed by the Nevada Department of Highways and built in 1937. NDOT's current view is that Lake Street Bridge is eligible for the National Register. The Corps is in the process of conducting its own evaluation of the bridge's eligibility for the National Register and will consult with SHPO on the results of that evaluation.

PUBLIC WORKSHOPS

A series of public workshops was initiated in the summer of 2001 to encourage as much community involvement as possible in the planning of the flood project, to help refine project alternatives for the downtown Reno portion of the project, and to seek the public's views on how best to provide flood protection in a manner that respects the value to the community of the Virginia, Sierra, and Lake Street Bridges. The first workshop was held on July 9, at which time input was obtained from the public on the range of flood protection options that should be analyzed for their hydraulic effect. A second workshop was held on August 9, at which time modeling results were presented, and the public suggested that additional options be studied. A third workshop was held on September 27, at which time five alternatives were presented and discussed.

POST-WORKSHOP CHANGES TO ALTERNATIVES

Subsequent to the workshops, discussions were held between representatives of the Corps, project sponsors, SHPO, and NDOT regarding the alternatives presented at the third workshop and their characterization. As a result, two of the alternatives presented at the third workshop have been either replaced or re-characterized. Details are found in the "Other Alternatives Considered" section of this report.

In addition, new but still preliminary information was developed regarding the margin of safety that should be added to floodwall heights. This margin of safety ensures that the structures are not under-designed for the actual hydrologic and hydraulic conditions at downtown Reno. At the time of the workshops, 2 feet of freeboard was the assumed margin of safety. Preliminary risk and uncertainty analysis conducted by the Corps indicates that the margin of safety is closer to 4 feet. As a result of this new information, the required containment heights for each of the five alternatives presented below have been changed to reflect a 4-foot margin of safety. Cost estimates have also been modified to reflect the increased floodwall heights.

EVALUATION CRITERIA

Criteria provide the basis for objectively and consistently evaluating alternatives. Eight criteria were used to assess individual flood damage reduction measures and evaluate alternative plans for the downtown Reno reach. The application of the criteria is explained below.

BRIDGE PRESERVATION

From a bridge preservation perspective, a measure or alternative is considered desirable if it addresses the flooding problem in a way which retains any historically significant bridges in downtown Reno (i.e., bridges listed or eligible to be listed on the National Register) and maintains their historic integrity or character.

REQUIRED CONTAINMENT HEIGHTS

Floodwalls contain floodflows within the Truckee River channel and help to minimize flood damage. However, they can hinder the public's ability to enjoy the river. Pedestrian views of the river can be impeded, as well as those of patrons of businesses whose river presentations are vital to their success. Under this criterion, alternatives

which result in lower floodwater surface elevations and lower required floodwall heights are more desirable.

Water surface elevations that would result from the alternatives were estimated by hydraulic modeling. Details regarding the modeling are provided in the Technical Appendix.

CONSTRUCTION COST

The Corps will not support construction of the flood project if the costs to reduce flood damages are so great that they exceed the benefits. (This was the major reason why the previously authorized regional project was suspended for several years.) In reviewing competing projects for funding, the Corps and Congress are likely to look more favorably on projects with higher benefit-to-cost ratios. In addition, lower project costs translate into lower required financial contributions from project sponsors. Consequently, measures or alternatives that limit construction costs are considered more desirable.

ECONOMIC REDEVELOPMENT

Flood damage reduction is intended to support the economic development of the downtown area. The City of Reno and the Reno Redevelopment Agency have articulated a vision for Reno's future, have adopted plans and development standards, and have made financial commitments towards implementing those plans. The aim is to increase public access to the Truckee River and to support active commercial uses that are enhanced by and contribute to a pleasing pedestrian interaction with the river. In turn, this interface between the river's edge and the downtown Reno central business district is intended to generate an increase in tourism, pride in the community, and a productive and diverse economic base. According to Reno's River Corridor Action Plan, the vision of the Redevelopment Agency is "to create vibrant, market driven entertainment and mixed-use development in the Truckee River Corridor which reflects Reno's cultural heritage

and attracts residents and visitors to the river…."

In line with this vision and strategy, tens of millions of dollars have been invested in a riverwalk on the south bank of the river, complete with cascading fountains, and in acquiring parcels along the riverfront such as the former Mapes Hotel site and the "midblock" parcel adjacent to the Masonic Building. A 25-foot setback from the river's edge has also been established for new buildings to allow for an esplanade to encourage outdoor dining, strolling, and window shopping. Building designs are expected to offer ground-level retail opportunities with adequate frontage devoted to windows.

Therefore, under this criterion, measures and alternatives are looked upon favorably that sustain or enhance Reno's ability to make active economic use of downtown land and are consistent with the vision of a pedestrian-oriented and economically vibrant river front environment.

DEBRIS

Debris that impedes the flow of water within the channel can exacerbate flooding, damage bridges and other structures, and pose safety risks of injury. Therefore, measures and alternatives are favored which would be likely to reduce the amount of debris that builds up in the downtown Reno reach of the river during a 1-percent chance flood event.

OPERATION AND MAINTENANCE

Measures and alternatives that require little or no additional upkeep after installation, as compared to what is currently necessary, are considered desirable since they do not place an additional burden on the City of Reno. Flood protection measures and alternatives are favored which do not depend upon rapid and successful deployment of emergency personnel during a flood event.

RIVERFRONT SAFETY

Roads and lanes along the riverfront provide access to the river and buildings for ambulances, fire trucks, and police vehicles. This access contributes to the safety of the people and structures surrounding and using the river area. Under this criterion, measures and alternatives that preserve this access to the riverfront help protect the community and are considered desirable. Measures which might create new hazards in or near the river channel are not considered desirable or acceptable by the City of Reno. Alternatives that require lower floodwalls offer the further advantage of decreasing emergency response times and, thereby increasing the local emergency service provider's ability to make river rescues.

RIVER ACCESS

The Truckee River is a major recreational, aesthetic, economic, and ecological asset to the region. The river is a public trust resource of local, regional, and state importance. A great deal of the community enjoys interacting with the river on a regular basis. Measures or alternatives that increase the public's ability to physically access the river are considered highly desirable.

ALTERNATIVES CONSIDERED

MEASURES INCLUDED IN ALTERNATIVES

Bridge Replacement

This measure consists of removing the existing bridge structures at Sierra, Virginia, and Lake Streets, and constructing new bridges in the same locations. There are two variations of this measure - replacement with Center Street type bridges and replacement with clear span bridges. In the first variation, the existing bridges would be

replaced with structures with a larger cross-sectional flow area and which would be similar in design to the existing Center Street Bridge, e.g., two piers and minimal deck height.

At Virginia Street, the new bridge would be similar to the existing Virginia Street Bridge with respect to deck width and vehicular capacity. The existing bridge is 80 feet wide, with four lanes of traffic, two lanes of parallel parking, and pedestrian sidewalks. Architectural components such as the original iron and concrete railing would be salvaged from the historic bridge and incorporated into the design of the new bridge.

The second variation of the bridge replacement measure uses the concept of replacement bridges that do not impede water conveyance. In theory, this would be accomplished by using a bridge design that does not rely upon structural support from piers below the deck as the existing bridges in the downtown Reno reach do. Instead, a clear span concept would be used in which support would be provided at the abutments and/or from above. This design could use a truss or suspension structure, a greater number of supporting beams in the structural web of the deck, arching of the bridge structure, raising of the existing road grade, or some combination of these options.

Floodwalls

Where existing floodwalls are structurally unsound or too low to adequately contain floodflows, this measure consists of removing existing floodwalls and constructing new floodwalls in their place. This approach would be followed along most of the north bank of the river from just upstream of Arlington Avenue down to Lake Street.

Within this north bank stretch, however, where vacant land is available or anticipated, floodwalls would be terraced. The containment structure would be set back up to 25 feet from the river with two or more terraced levels to provide increased river

access and opportunities for recreation. Terraced floodwalls could be designed to be similar to the recently constructed riverwalk on the south bank, or similar to the West Street Plaza ("Brick Park"). Designs which incorporate landscaping into the horizontal terraces would most likely be considered in the final design.

Where existing floodwalls are structurally adequate, additional containment height is required. Because setting back the line of containment is practical, new floodwalls would be constructed that are set back approximately 25 feet from the river edge, closer to the structures to be protected, in an effort to design a pedestrian-oriented environment at the interface between the river's edge and the riverwalk to foster enjoyment of the river and to plan flood damage reduction features that are compatible with the City of Reno Redevelopment Plan for the downtown Reno reach.

Two lengths of existing floodwall would not be replaced in this measure because of course these portions of floodwall are relatively new. These two portions of floodwall include the Truckee River Fountain Walk located along the south bank between Sierra Street and Virginia Street, and West Street Plaza ("Brick Park") located immediately downstream of the pedestrian bridge to Wingfield Park. If additional containment height is required at these locations, the floodwall would be set back from the river's edge.

On the north bank upstream of Arlington Avenue and south of Riverside Drive, setback floodwalls would be constructed. Incorporated into the setback floodwalls would be an earth filled berm to blend the structure into the existing park-like setting.

In all floodwall locations, there are opportunities to incorporate architectural and craftsmen elements into the final design. The aesthetic appeal of floodwalls can be enhanced by using textured treatments, coloration, and stamped patterns. Construction of new floodwalls within downtown Reno reach of the Truckee River may also create opportunities to incorporate public art into the final design.

If there are specific locations where neither setback nor terraced floodwalls are practical and where outright replacement of existing floodwalls would conflict with the needs of the City of Reno due to aesthetic or other concerns, design approaches for adding height to and/or structurally reinforcing the existing floodwall will be investigated and considered further.

Channelization

This measure consists of removing the existing diversion structure located upstream of the Arlington Avenue Bridge, removing the sediment which it has trapped, and regrading the channel bottom to create a more uniform channel slope from Virginia Street upstream to a point approximately 1,500 feet above Arlington Avenue. This measure would reduce velocity variances, prevent localized scour, reduce water surface elevations upstream of Arlington Avenue, and decrease the likelihood of additional sediment deposition between Virginia Street and Arlington Avenue.

Widening

This measure involves widening the river channel on the north bank from approximately Sierra Street to Lake Street to provide additional flow area. The widening would begin 2 vertical feet above the existing channel bottom and extend horizontally 12½ feet into the planned riverwalk. This flood damage reduction measure would be implemented through the majority of the Sierra to Lake Street reach with the exception of the city block that contains the AT&T building. Through this block, the channel would be widened by only 6 feet on the west and east sides of the AT&T building. There would be no widening along the front of the AT&T building.

In conjunction with this measure, any replacement bridges at Sierra or Virginia Streets would need to be longer than the existing bridge spans due to the wider channel. Similarly, a “mini” span would be required at any bridge that is not replaced where

widening occurs. A culvert at Lake Street Bridge would also be constructed in conjunction with this measure so that the additional flow area made possible by the widening could continue through the bridge location.

Mini Spans

In conjunction with the channel widening measure is the addition of a partial or mini span to the existing Center and/or Sierra Street Bridges. Architecturally, each new mini span would resemble the current bridge spans. Where widening is implemented but a bridge is not replaced, the mini spans would be necessary to connect the existing bridges with the new channel bank. This would provide an increase in the flow area at the bridge without requiring replacement of the entire bridge. For the Widening Alternative, a mini span would be added only at the Center Street Bridge. The Rehabilitation - New Span Alternative would include mini spans at both Center and Sierra Street Bridges.

Culvert around Replaced Lake Street Bridge

This measure provides for the installation of a culvert around Lake Street Bridge on the north side of the river. The culvert would direct excess flow around the bridge abutments, thereby increasing flow capacity. This measure would be implemented only in conjunction with the widening measure. A culvert would be required to accommodate the additional flow made possible by widening because physical constraints (AT&T building) make lengthening of Lake Street Bridge infeasible.

Plazas

Plazas provide open areas on the north bank of the river into which floodwaters can flow. The idea of including plazas in the flood project was advocated by participants at the first public workshop on July 9, 2001, and was further encouraged by participants at the second workshop. Plazas would begin at the north edge of the river, 2 feet above

the bottom of the river channel, and extend perpendicularly from the river as far as the south side of First Street. One plaza would be placed between Sierra and Virginia Streets, using the entire block now occupied by the Masonic building, and the second plaza would be placed at the former Mapes block.

Containment at First Street

This measure would set floodwalls north of the river back to First Street between Arlington Avenue and Center Street. This measure is intended to provide additional flow capacity beyond that of the river channel itself. The concept was based on an understanding of the 1997 flood event during which a noticeable amount of water flowed down First Street. The suggestion to consider this measure was made by members of the public who attended the second public workshop on August 9, 2001.

New Span at Virginia Street Bridge

This measure would add a third span to the north side of the Virginia Street Bridge. It would be implemented in conjunction with the plazas measure. Adding the third span would provide a direct hydraulic connection between the plazas and allow additional flow to pass through the bridge openings. The new span would be designed to have a similar appearance as the existing spans.

Bridge Rehabilitation

Under this measure, the bridges at Sierra, Virginia, and Lake Streets would be rehabilitated while maintaining their historic integrity. This rehabilitation would reinforce the bridges' structures, increasing their lifespan by approximately 25 years. In addition, it is assumed that the rehabilitation would be completed in a way that does not destroy the historic character of any of the bridges. The rehabilitation of Virginia Street Bridge would be conducted according to plans being developed by NDOT in consultation with SHPO. No detailed plans have been developed for the Lake and Sierra Street Bridges.

Floodproofing

This measure involves floodproofing structures that are expected to be inundated during a flood to prevent damage to the structure and its contents. Each alternative involves floodproofing of the structures in Barbara Bennett Park and the Riverside Apartments building. If containment at First Street is implemented, it would require additional floodproofing for structures between First Street and the river, from Arlington Avenue to Center Street.

MEASURES PREVIOUSLY CONSIDERED AND ELIMINATED

Bridge Preservation

In this measure, the bridges at Sierra, Virginia, and Lake Streets would be preserved with only minor improvements. Without major structural improvements, the Virginia Street Bridge would need to be closed to vehicular traffic within a few years due to deterioration of structural conditions.

SHPO and NDOT have stated that major structural improvements can be made to Virginia Street Bridge without jeopardizing its historic character. Consequently, the Bridge Rehabilitation measure is considered preferable and has been substituted for the Bridge Preservation measure.

Bridge Reconstruction

This measure would structurally reinforce the Virginia, Lake, and Sierra Street Bridges without changing their outward appearance. However, fundamental changes would occur to the bridges' interior structures that have been considered likely to adversely affect their character. This measure was originally proposed to be distinguished from the Bridge Preservation measure. However, both the Bridge Preservation measure

and the Bridge Reconstruction measure have been eliminated from further consideration since it is now assumed that rehabilitation of the bridges can be accomplished in a manner which sustains both their utility and their character. Consequently, the Bridge Rehabilitation measure has been incorporated into alternatives that are evaluated further in this report, but the Bridge Reconstruction and Bridge Preservation measures have been eliminated.

Variations of Floodwalls

This measure consists of removing existing inadequate floodwalls through the downtown Reno reach and replacing them with floodwalls that are of types other than those described under the floodwalls measure. Variations of floodwalls include a movable barrier floodwall system (MBFS), modular floodwalls, and tilt-up floodwalls.

The MBFS is an automatic levee/floodwall system that theoretically operates solely by the buoyant forces of water. The MBFS is designed to keep at least 50 percent of its height inside the concrete channel when fully extended to provide support. The MBFS is estimated to last between 50 and 75 years.

Modular floodwalls consist of interlocking panels assembled on a base system at ground level. The system typically consists of a concrete base with a guide and gasketed lock mechanism. Before flood events, lightweight wall panels are manually installed into the existing base system and locked into place. The wall panels are removed when the flood danger has passed.

Tilt-up floodwalls consist of concrete footings and/or base with hinged walls. The hinged walls, typically steel, lay flat against the ground surface when not in use. During flood events, these structures are raised to an angle near 90 degrees with the ground surface, raising the effective height of the flood control structure.

Each of these floodwall designs is no longer considered for various reasons. The MBFS was eliminated due to concerns about cost and because it lacks a history of successfully applied performance. Both the modular and the tilt-up floodwalls were eliminated due to the high labor requirements before, during, and after flood events.

Channel Deepening at Bridges

This measure consists of reconstructing the river channel beneath selected bridges in the study area, thereby deepening the river channel between the bridge footings. It would remove material beneath the Arlington, Sierra, Virginia, Center, and Lake Street Bridges and regrade the channel floor immediately upstream of each bridge. Deepening the channel would increase the cross-sectional area beneath the bridge structures, facilitating passage of large flows during flood events.

One potential problem involves sediment redepositing in these areas after initial dredging and regrading.

This measure was dropped from further consideration because of the minimal effects on lowering water surface elevations through the study area, the potential for scour to undermine the bridges during high velocity flows, and the potential maintenance requirements to frequently remove sediment which would be likely to reaccumulate over time.

Culverts around Existing Bridges

This measure provides for the installation of culverts which direct excess flow around the bridge abutments. Culverts would divert flow immediately upstream of the bridge and return the flow to the river channel immediately downstream of the bridge structure. These culverts could be located on either the north, south, or both banks at the various bridge locations. The culverts would be roughly 10-foot by 10-foot pre-cast

concrete structures. The installation of culverts around the abutments of the bridge would enlarge the flow area, thus increasing the channel capacity.

This flood management measure was not eliminated from consideration during plan formulation primarily because it would not add sufficient flow capacity to the existing bridge structures. This measure combined with the cross-sectional flow areas of the existing bridges would not pass 100-year flows. Culverts also provide increased opportunity for debris to accumulate at the bridges, which would undermine the effectiveness of any additional flow capacity created. In addition, concerns have been expressed that in-stream culverts would pose a hazard to recreational users of the river or to homeless people that might use them as resting locations, and could complicate river rescues.

Bypass Channel

This measure consists of constructing a new channel to bypass the downtown Reno reach of the Truckee River. A bypass channel would divert excess floodflows upstream of downtown Reno into a new channel. Flow in the channel would reenter the main Truckee River below the downtown reach.

This measure was eliminated from further consideration due to the lack of available land and concerns about cost.

Remove the Lower Bridge at Wells Avenue

This measure involved removing Wells Avenue's lower bridge to prevent backwater effects upstream of the bridge. This measure was deemed unnecessary when it was determined that the damage caused by the backwater effects at this location and any overbank flow were not significant enough to justify the cost of the bridge removal. It was also considered unnecessary because the upper Wells Avenue Bridge provides a

route for traffic to cross the river at this location during a flood.

Arlington Avenue Bridge Replacement

This measure would replace the Arlington Avenue Bridge, which is actually composed of two separate bridges connecting Wingfield Park to the north and south banks of the river. A small section of roadway joins the two bridges. The bridge carries four lanes of through traffic, plus a turning lane.

Due to the island located between the two portions of the bridge and the existing bridge's significant width, a large causeway would have to be constructed to create a bridge whose deck was elevated above floodflows, which would make it a costly measure. In addition, hydraulic modeling indicates that this measure would not significantly lower water surface elevations. This measure was eliminated from further consideration due to expectations that it would be costly and provide minimal hydraulic benefit.

Widening on South Bank

Similar to the widening measure on the north bank of the river, this measure consists of widening the channel on the south bank. The south bank widening measure would begin just upstream of Sierra Street and end at Center Street.

This measure was eliminated since it would require demolition of the existing riverwalk improvements, a valuable community and recreational asset.

Upstream Storage/Detention

This measure involves acquiring land upstream of the downtown reach to use as storage to detain floodwaters at least until the flood peak has passed. Storage during

flood events could alleviate the need for modifications to the downtown reach.

It is estimated that on the order of 4,000 acre-feet of upstream storage would be needed to reduce the flood event peak sufficiently to pass under the existing Virginia Street Bridge. The financial costs and potential environmental effects of an adequately sized storage facility caused this measure to be eliminated from further consideration, along with identified constraints associated with specific sites.

Downtown Buyout

This measure involves purchasing all buildings and parcels on the north bank from Sierra Street through Lake Street. The buildings would be removed, and these vacant lots would become part of the channel. Starting from the existing bottom of the channel and extending to First Street, this measure would resemble the plaza concept, but would not be limited to the Mapes and mid-block sites. The intent of this measure was to increase flow area without removing those bridges constructed prior to 1940, as well as to potentially reduce flood damages by simply eliminating at-risk structures.

This measure was discarded because it is expected that the cost associated with land acquisition and excavation would be prohibitive.

ALTERNATIVES EVALUATED

Rehabilitation Alternative

This alternative would increase flood protection in the downtown Reno reach of the Truckee River by incorporating the following measures:

- Bridge rehabilitation
- Floodwalls
- Channelization
- Floodproofing

This alternative would rehabilitate the Sierra, Lake, and Virginia Street Bridges and extend their lifespan by about 25 years.

Rehabilitation – New Span Alternative

This alternative would increase flood protection in the downtown Reno reach of the Truckee River by incorporating the following measures:

- Bridge rehabilitation
- Widening
- Plazas
- New span at Virginia Street
- Culvert around Lake Street Bridge
- Mini spans at Sierra and Center Street
- Floodwalls
- Containment at First Street
- Channelization
- Floodproofing

This alternative would provide the best hydraulic results possible without replacing the pre-1940 bridges.

Matching Bridges Alternative

This alternative would increase flood protection in the downtown Reno reach of the Truckee River by incorporating the following measures:

- Bridge replacement (Center Street design)
- Floodwalls

- Channelization
- Floodproofing

This alternative increases channel conveyance through the downtown reach principally by replacing the existing bridges at Sierra, Virginia, and Lake Streets with new bridges whose design and architecture would be similar to that of the Center Street Bridge. The Center Street Bridge was built in 1996, is capable of passing the design flow of 20,700 cfs, and blends architecturally with the U.S. Post Office and nearby floodwall railings on the river side of the building. Use of a design similar to the Center Street Bridge would provide a consistent and coherent architectural theme.

Landmark Bridges Alternative

This alternative would increase flood protection in the downtown Reno reach of the Truckee River by incorporating the following measures:

- Bridge replacement (clear span design)
- Floodwalls
- Channelization
- Floodproofing

This alternative is identical to the Matching Bridges Alternative except that a bridge without any supporting structures located in the river, i.e., a clear span, would be constructed instead of a Center Street type bridge.

Widening Alternative

This alternative would increase flood protection in the downtown Reno reach of the Truckee River by incorporating the following measures:

- Widening
- Culvert around Lake Street Bridge
- Mini span at Center Street
- Bridge replacement (Center Street design)
- Floodwalls
- Channelization
- Floodproofing

This alternative creates additional flow capacity by widening the river channel and reduces constrictions by replacing the pre-1940 bridges with Center Street Bridge configurations.

OTHER ALTERNATIVES CONSIDERED

Beyond the five alternatives listed above, a number of other alternatives were also considered. They were eliminated either because the measures they contained were ineffective or because the alternative as a whole did not perform well hydraulically. The remainder of this section describes in more detail the other alternatives that were considered, but not carried forward into the five alternatives that are evaluated in the plan formulation process documented in this report.

Table 2
Alternatives Summary

Alternatives	Channelization	FW's/ Levees	Replace Bridges	Rehabilitate Bridges	New Span @ Virginia St.	Channel Widening	Culvert @ Lake St.	Mini Span(s)	Plazas	Containment @ 1st St.	Comments
Existing Conditions											
Rehabilitation	X	X		X							
Rehabilitation - New Span	X	X		X	X	X	X	X	X	X	Mini span at Sierra and Center St. Bridges
Matching Bridges	X	X	X								
Landmark Bridges	X	X	X								
Widening	X	X	X			X	X	X			Mini span at Center St. Bridge only

Several alternatives were considered which involved widening on both the north and south banks. These alternatives were discarded because they would require destruction of the economically valuable riverwalk on the south bank.

A variation of the Widening Alternative was considered which involved replacement of Lake and Sierra Street Bridges with Center Street type bridge designs. Unlike the Widening Alternative, however, this variation did not involve replacement of the Virginia Street Bridge. Despite including a mini span to increase hydraulic capacity at the bridge, leaving the Virginia Street Bridge in place created a large constriction and significantly raised water surface elevations upstream of the bridge. Consequently, this Widening Alternative variation was eliminated from further consideration.

A variation of the Rehabilitation Alternative was considered which involved plazas and containment at First Street, but it replaced the pre-1940 bridges with Center Street type bridge designs. Containment at First Street and the use of plazas were suggested at the second public workshop as means to aid in flow conveyance and thereby enable preservation of the pre-1940 bridges. Therefore, replacing the pre-1940 bridges would be contrary to the intent of the containment at First Street and plazas measures. Consequently, this variation was set aside.

An alternative labeled the Preservation Alternative was presented in the third public workshop held on September 27, 2001. Since that time, it has been replaced with the Rehabilitation Alternative, which better sustains the functionality of the pre-1940 bridges while still maintaining their character. However, from a hydraulic perspective, the Preservation Alternative discussed at the public workshop is identical to the Rehabilitation Alternative evaluated in this report.

An alternative labeled the Reconstruction Alternative was also presented in the third public workshop. It proposed to "reconstruct" the pre-1940 bridges, which was believed at that time would be detrimental to the integrity of the bridges' character. The

alternative also involved the addition of two plazas at the Masonic and former Mapes sites, and provided for containment at First Street. There was no direct hydraulic connection between the two plazas because it was believed that addition of a "new span" to the Virginia Street Bridge would threaten its historic character and integrity. Without a hydraulic connection between the plazas, the alternative yielded poor hydraulic results. This alternative has been discarded in favor of the new Rehabilitation – New Span Alternative that includes rehabilitation of the pre-1940 bridges, a new span at Virginia Street Bridge, and two hydraulically connected plazas on either side of the bridge.

Although a complete evaluation of these other alternatives is not provided in this report, the results from the hydraulic modeling are presented in the Technical Appendix.

EVALUATION OF ALTERNATIVES

This portion of the report evaluates five alternatives, using the criteria described in detail in previous sections of this report. Each alternative is presented in turn, with a description of its advantages or disadvantages under each criterion. As will be seen, tradeoffs are implicit in the alternatives. Relatively low floodwall heights can be achieved, but only by sacrificing bridges built before 1940, land designated by the City of Reno as a redevelopment corridor, or both.

REHABILITATION ALTERNATIVE

Bridge Preservation

The aim of this alternative is to rehabilitate the bridges in a manner that maintains the character of the Sierra, Lake, and Virginia Street Bridges while adding to their lifespans. This alternative satisfies the bridge preservation criterion.

Required Containment Heights

In this report, the discussion of water surface elevations and required containment heights focuses on the portion of the river starting from above Arlington Avenue down to Lake Street. This is the portion of the river reach in which the alternatives differentiate themselves. Above and below this portion of the reach, the alternatives have essentially the same effects. Details of the modeling process are provided in the Technical Appendix, along with an explanation of how floodwall heights were determined.

Water surface elevation profiles for each alternative and for existing conditions are shown in Figure 1. Existing conditions serve as a point of reference. In several parts of the downtown reach, the water surface elevations for existing conditions are at or significantly above the floodwalls now in place at the river channel's edge.

Table 3 shows the heights of new containment structures that would be required under each alternative, relative to sidewalk elevation at recognizable locations. The numbers shown in Table 3 represent the additional containment height that would be required beyond what is provided by the current floodwalls.

The Rehabilitation Alternative provides the least hydraulic benefit of the five alternatives evaluated. It would result in water surface elevations higher than under existing conditions, primarily due to the confinement caused by floodwalls. Floodwalls would need to be built 4 to 8 feet higher than current sidewalk elevation to reduce flood damages to downtown buildings and their contents.

Table 3

Required Containment Height[1]

Left Bank (North Bank)

Left Bank Landmark	River Station	Rehabilitation	Rehabilitation - New Span	Matching Bridges	Landmark Bridges	Widening
S.W. corner Arlington & 1st St.	52.335	7.5	6.2	6.3	3.5	4.9
Arlington						
Mini-Park S.E. corner Arlington & 1st St.	52.292	6.1	3.8	4.0	0.7	2.1
Sierra St.						
Vacant portion of Masonic Block	52.148	6.1	1.9	4.1	0.6	0.5
E. end of Masonic bldg.	52.097	5.7	2.7	3.7	0	0.8
Virginia St.						
E. end of Mapes block	52.021	7.1	4.3	5.5	3.4	3.4
Center St.						
AT&T bldg.	51.990	4.2	2.8	2.6	0.6	1.4
Lake St.						

Right Bank (South Bank)

Right Bank Landmark	River Station	Rehabilitation	Rehabilitation - New Span	Matching Bridges	Landmark Bridges	Widening
Bluff	52.760	0	0	0	0	0
Barbara Bennett Park	52.335	9.5	8.2	8.3	5.5	6.9
Arlington						
Park Towers	52.292	7.2	4.9	5.0	1.8	3.2
Trinity Church	52.210	8.2	5.8	6.1	2.2	4.1
Sierra St.						
W. end Riverside Apts block	52.148	6.1	3.7	4.1	0.6	0.9
Riverside Apts.	52.097	5.4	0	3.4	0	0.4
Virginia St.						
E. end Post Office block	52.021	4.3	3.0	2.6	0.5	1.3
Center St.						
Siena Hotel	51.990	4.2	2.8	2.6	0.6	1.4
Lake St.						

1. Difference, in feet, between modeled water surface elevation and bank elevation (sidewalk level). Includes margin of safety of 4 feet.

Economic Redevelopment

The alternatives which best preserve the goals of the Redevelopment Agency are those that preserve the existing land surrounding the river in which the Agency has already invested. In this regard, the Rehabilitation Alternative is viewed as favorably as any other alternative. In a few locations terraced floodwalls would impinge upon the redevelopment setback, but otherwise lands designated for redevelopment would not be affected.

However, the relatively high floodwalls of this alternative would detract from the pedestrian-oriented, river corridor environment which redevelopment seeks to enhance.

Construction Cost

Table 4 provides a summary of construction costs for each alternative. In the table, the alternatives are listed from least to greatest cost. Details regarding cost estimates are contained in the Technical Appendix. The Rehabilitation Alternative has the lowest initial cost of the five alternatives at $23.8 million.

Table 4

Construction Costs for Alternatives

Alternatives	Construction Costs (Yr. 2001 dollars)	Contingency, Design, Cultural Resources, and Construction Management (39%)	Land Acquisition Costs	Total Construction Costs
Rehabilitation	$14,945,629	$5,858,686	$2,970,353	$23,774,668
Landmark Bridges	$17,443,330	$6,837,785	$2,970,353	$27,251,468
Matching Bridges	$18,111,804	$7,099,827	$2,970,353	$28,181,984
Widening	$21,008,881	$8,235,481	$2,942,368	$32,186,730
Rehabilitation - New Span	$17,618,457	$6,906,435	$14,095,467	$38,620,359

Debris

Under existing conditions, debris easily accumulates during a flood event at those bridges constructed prior to 1940 due to their limited flow area. Rehabilitating the bridges would not improve current debris conditions.

Operation and Maintenance

Operation and maintenance requirements for this alternative would be similar to those that now exist for downtown Reno, except that rehabilitation of the bridges would reduce bridge maintenance requirements.

Riverfront Safety

This alternative maintains the existing riverfront safety conditions since it does not modify the existing 25-foot-wide access road.

Improving River Access

Currently, direct river access in the downtown reach is provided principally at the steps leading down from West Street Plaza ("Brick Park").

The only additional access points that would be provided by the Rehabilitation Alternative would be located immediately downstream of Lake Street where it is anticipated that terraced floodwalls could be constructed. Otherwise, the alternative does not provide any additional access locations in the downtown area.

REHABILITATION – NEW SPAN ALTERNATIVE

Bridge Preservation

This alternative aims to maintain the character of the pre-1940 bridges while extending their lifespans. A new span added to Virginia Street Bridge would be designed to be architecturally similar to the existing bridge. The same is true for Sierra Street Bridge. It is presumed that this could be done in a manner that maintains the character of the bridges. Therefore, this alternative satisfies the bridge preservation criterion.

Required Containment Heights

This alternative reduces water surface elevations relative to existing conditions. The additional flow area created by the widening more than compensates for the confining effects of building higher floodwalls than now exist. The range in required containment walls for this alternative is 3 to 6 feet in height above current sidewalk elevations.

Economic Redevelopment

The Rehabilitation – New Span Alternative is most in conflict with the economic redevelopment criterion of any of the alternatives. The widening measure would eliminate half of the width of the current sidewalk level land associated with the redevelopment setback on much of the north bank. This conflicts with the development of an economically active esplanade suitable for window shopping and dining at sidewalk cafes.

In addition, this alternative would forfeit the active economic use of the land required for construction of the plazas. By providing passive public spaces, it would be contrary to Reno's adopted redevelopment goals and objectives for the downtown river corridor.

Construction Cost

This alternative is the most expensive at $38.6 million. This is due to the high land cost associated with the plazas measure and the expense of adding new spans to the bridges in addition to rehabilitating them.

Debris

Although this alternative would increase flow area through the pre-1940 bridges, the new span at Virginia Street, the mini spans at Sierra and Center Street Bridges, the culvert at Lake Street Bridge, and the new plazas would create new locations where debris can accumulate.

Operation and Maintenance

Bridge maintenance would be mostly comparable to that required for the other alternatives, but there would be a slight increase in maintenance requirements due to the widening of the channel, the installation of the culvert at Lake Street, and the new spans and mini spans at the downtown bridges.

Riverfront Safety

Pedestrian access to the river would be increased with the addition of the plaza. However, the plazas and the widening would eliminate a great deal of the 25-foot lane on the north bank that parallels the river, interfering with emergency service provider access and response times. In addition, the culvert at Lake Street Bridge could create additional hazards to river users.

Improving River Access

Additional river access would be provided at the plaza location, as well as downstream of Lake Street where a terraced floodwall would be added on the north bank. Widening would also create more public interaction with the river.

MATCHING BRIDGES ALTERNATIVE

Bridge Preservation

Replacing the Sierra, Virginia, and Lake Street Bridges would be contrary to the bridge preservation criterion.

Required Containment Heights

The Matching Bridges Alternative results in a decrease in water surface elevations of about 1 foot as compared to existing conditions. The replacement of downtown bridges constructed prior to 1940 more than compensates for the confining effects of building higher floodwalls than now exist. Containment walls for this alternative range from 2.5 to 6 feet in height above current sidewalk elevation, which is comparable to the Rehabilitation – New Span Alternative.

Economic Redevelopment

Terraced floodwalls used in this alternative do impinge upon the redevelopment setback in a few locations, but otherwise lands designated for redevelopment would not be affected.

Construction Cost

This alternative's construction cost is the third greatest at $28.1 million.

Debris

This alternative would significantly reduce the likelihood of debris accumulation at the pre-1940 bridges. The additional flow area created by the bridge replacements would allow more debris to continue to travel downstream.

Operation and Maintenance

This alternative is comparable to existing conditions, except that maintenance costs for the pre-1940 bridges would be reduced.

Riverfront Safety

This alternative maintains the existing riverfront safety conditions since it does not modify the existing access road.

Improving River Access

New access points are available where terraced floodwalls would be used on the north bank of the river. In addition to the new access point below Lake Street, this alternative would provide new access at the Masonic mid-block area and the former Mapes block.

LANDMARK BRIDGES ALTERNATIVE

Bridge Preservation

Replacing the Sierra, Virginia, and Lake Street Bridges would be contrary to the bridge preservation criterion.

Required Containment Heights

The Landmark Bridges Alternative provides the greatest hydraulic benefit of all the alternatives evaluated. It results in a net decrease in water surface elevations of 3 to 7 feet as compared to existing conditions. Containment heights range from 1.5 to 3.5 feet above current sidewalk level.

Economic Redevelopment

Terraced floodwalls used in this alternative do encroach into the redevelopment setback in a few locations, but otherwise lands designated for redevelopment would not be affected.

The Landmark Bridges Alternative's relatively low floodwall heights would most enhance the visual experience along the river and be most consistent with the objectives and designated land uses of the redevelopment esplanade as stated in the River Corridor Action Plan.

Construction Cost

Despite the similarity in modifications to the channel as the Matching Bridges Alternative, the cost of this alternative is slightly less at $27.3 million. The bridge replacement costs are assumed to be comparable to the Matching Bridges Alternative. The slight reduction in cost is due to the clear span bridges' effectiveness in reducing the

heights of the containment walls. A decrease in required containment material reduces the cost of construction.

Debris

The Landmark Bridges Alternative is the best of all the alternatives on this criterion. It would provide even better results than the Matching Bridges Alternative. The clear spans would provide even greater flow area and no bridge piers, further decreasing the potential for debris to accumulate at the bridges.

Operation and Maintenance

This alternative is comparable to existing conditions, except that maintenance costs for the pre-1940 bridges would be reduced.

Riverfront Safety

The significant reduction in required floodwall heights facilitates rescue efforts at the river's edge in the downtown area, relative to the other alternatives.

Improving River Access

New access points are available where terraced floodwalls would be used on the north bank of the river. In addition to the new access point below Lake Street, this alternative would provide new access at the Masonic mid-block area and the former Mapes block.

WIDENING ALTERNATIVE

Bridge Preservation

Replacing the Sierra, Virginia, and Lake Street Bridges would be contrary to the bridge preservation criterion.

Required Containment Heights

The Widening Alternative reduces water surface elevations by 2 to 4 feet as compared to existing conditions. Required containment heights range between 1.5 and 5 feet, the second lowest of the five alternatives.

Economic Redevelopment

The Widening Alternative would require elimination of half of the current sidewalk level redevelopment setback on the north bank. This conflicts with the local objective for development of an economically active esplanade suitable for window shopping and dining at sidewalk cafes.

Construction Cost

This alternative is the second most expensive alternative at $32.1 million. The higher cost is due to the excavation of the channel and the additional bridge lengths that are required under the widening measure.

Debris

The Widening Alternative would in part provide similar results as the Matching Bridges Alternative due to the bridge replacement. It would also create additional flow area through which debris could pass due to the widening measure, but new debris

accumulation may occur at the culvert placed on the north bank of the Lake Street Bridge and at the mini span at Center Street.

Operation and Maintenance

Bridge maintenance would be comparable to that required for the other alternatives, but there would be a slight increase in maintenance requirements due to the widening of the channel, and the installation of the culvert at Lake Street and the mini span at Center Street.

Riverfront Safety

The widening measure halves the width of the existing emergency access road, making emergency vehicle mobility difficult. It also includes a culvert at Lake Street that can pose a hazard to river users. However, relatively low floodwall heights and the potential to get closer to the river in the newly widened area could be useful for river rescues not requiring vehicles.

Improving River Access

Additional river access is provided through the widening measure. As the widening is planned above the low-flow elevation, this would allow for greater public interaction with the river throughout most of the downtown reach.

CONCLUSION

This report presents information intended to assist decision makers in determining the best options for reducing flood damages in the downtown Reno area. Trade-offs between criteria are apparent in several of the alternatives, and each alternative offers a unique combination of positive and negative aspects. The Landmark Bridges Alternative offers the lowest floodwall heights and an opportunity to introduce new designs for public infrastructure. The Matching Bridges Alternative would provide architectural consistency. The Rehabilitation Alternative and the Rehabilitation – New Span Alternative offer the opportunity to rehabilitate and to keep in place the existing pre-1940 bridges. The Rehabilitation, Matching Bridges, and Landmark Bridges Alternatives offer high levels of consistency with ongoing downtown redevelopment.

The selection of a preferred alternative is left to the project sponsors, in consultation with the public and other governmental agencies.